Fault Location in Active Distribution Networks Containing Distributed Energy Resources (DERs)

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Background and motivation:

✓ Impedance-based methods are known to have limitations in distribution networks, especially in the presence of inverter-based power sources (IBPS).

✓ Fault Location in Distribution Networks with multiple IBPSs may be challenging when the networks contain a mixture of 3-phase, 2-phase and single-phase overhead and underground cables.

✓ Develop an effective and accurate fault location method based on the traveling wave method and discrete wavelet transform.

Technical approach:

✓ Through the placement of Digital Fault Recorders (DFRs) in each line terminal, the arrival times generated by transient faults are then registered.

✓ The terms of fault occurrence time $t_f$, faulted section $s$, and fault distance $X$ are derived from figure 1.

✓ Using the previous equations, the matrices of faulted section $S_{DFR}$, fault occurrence time $T_{DFR}$ and fault location $X_{DFR}$ are then computed.

✓ The array $D$ can be estimated using the previous matrices which contain fault distances that are approximately equal.

Conclusion:

✓ The method doesn’t require the identification of faulted lateral to determine the accurate fault location.

✓ The difference of traveling wave speed between line and cable are deleted through the identification of faulted section.

✓ Using median method in the array $D$, outliers as synchronization time errors can be identified and deleted from the evaluation.

✓ The disconnection of distribution lines are also identified by the proposed method, it behaves as an extreme outlier.

✓ It can be applied to small and large distribution networks with a complex mix of overhead lines and cables in the presence of IBPSs.
The goal is to estimate the $D$ array, which contains the fault distances calculated by different DFR pairs. These distances have to be approximately equal.

$$X(t) = V_s(t_R - t_f(R_j)) = V_s(t_R - t_f(R_j)) - \sum_{i=1}^{n} V_t \tau_i$$

$$D = \begin{bmatrix} X_1 & X_2 & \ldots & X_{k+1} & X_{k+2} \end{bmatrix}$$
The mean estimated from the D array is 37.495 km, then by comparing it with the real distance 37.5km, the error is 0.0133%.
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